UNDERSTANDING OF GEOMETRIC CONSTRAINT EFFECTS IN PLASTICITY MODELING OF TWO-PHASE NI-BASE SINGLE CRYSTALS

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Literature reports [1, 2] suggest that deformation incompatibility between the soft γ matrix and hard γ′ precipitates plays a significant role in thermo-mechanical responses of two-phase single-crystal superalloys, particularly for those having a high volume fraction of cuboidal γ′ precipitates. This study focused on how such geometric constraints influence macroscopic flow responses of a single-crystal superalloy, CMSX-4, by modeling the elasto-viscoplastic behaviors of γ and γ′ using a "Unit Cell" [3] approach as the γ/γ′ microstructural representation. The constitutive description used for the γ-phase matrix basically followed the frame work of the rate- and scale-dependent model proposed by Acharya and Beaudoin [4], that incorporated a gradient-dependent slip-plane lattice incompatibility and the 1-parameter hardening model proposed by Kocks, Estrin and Mecking. However, some modifications were made to the 1-parameter model based on metallurgical observations. The γ′-precipitates were treated separately by an elastic model and by an elasto-viscoplastic model, and the simulation results were compared. Mechanistic details regarding an occurrence of flow softening (in the material and the simulations) were also investigated. The simulation results were analyzed in the context of metallurgical understanding of the material.

References

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